

Simulation of The Earth Spectral Reflectance Over Large Time and Space Scales

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CLARREO's climate benchmark concerns radiation averaged over large space and time scales.

Direct measurement of the reflected solar spectrum from space has been limited in temporal and spectral sampling.

Spaceborne sensors have measured the atmospheric and surface properties over globe for decades and have accumulated a large volume of instantaneous measurement data. It is formidable to simulate the mean spectral radiance over large climate domains by explicit RT computations at the satellite footprint scales.

A simplifying approach has to be developed to use the instantaneous satellite data efficiently.

We have developed an efficient and effective approach to do this!

Table 1. The Data Sets Used

Sensor	Measurement	Spectral range	Platform
SCIAM	Spectral radiance solar irradiance	0.25 – 2.38 µm ($\Delta\lambda$: 0.24-1 nm)	Envisat
MODIS/ CERES	Spectral radiance, cloud, aerosol, PW, BRDF, ...	Different spectral bands	Terra

Plus SMOBA ozone and SeaWiFS Chlorophyll concentration.

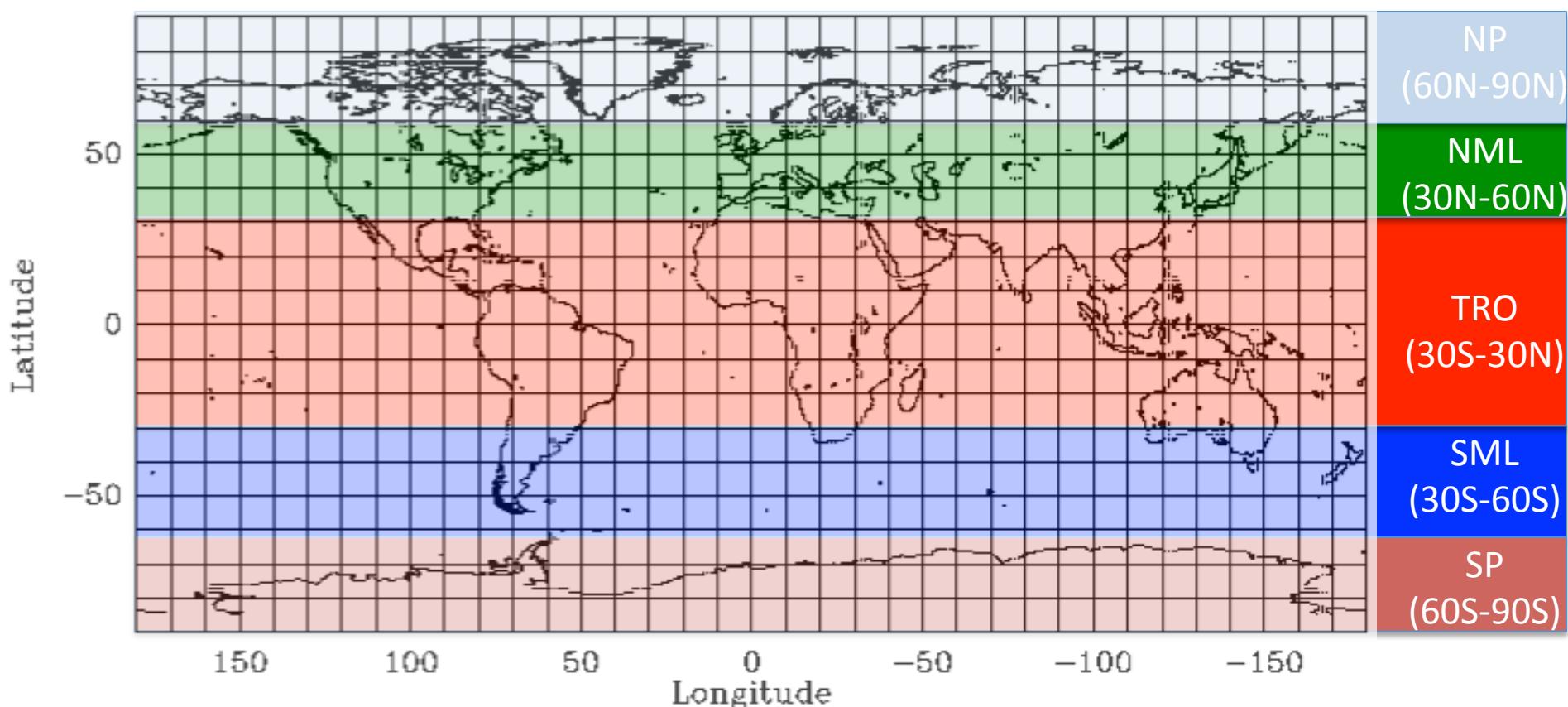
Envisat and Terra have similar sun-synchronous orbits:

Satellite	Altitude	Inclination	Period	Equator crossing
Envisat	799.8 km	98.6°	100.6 min	10:00 LST
Terra	705 km	98.2°	98.8 min	10:30 LST

Data average in each month: 5×5 deg grid \rightarrow 5 deg latitude zones.

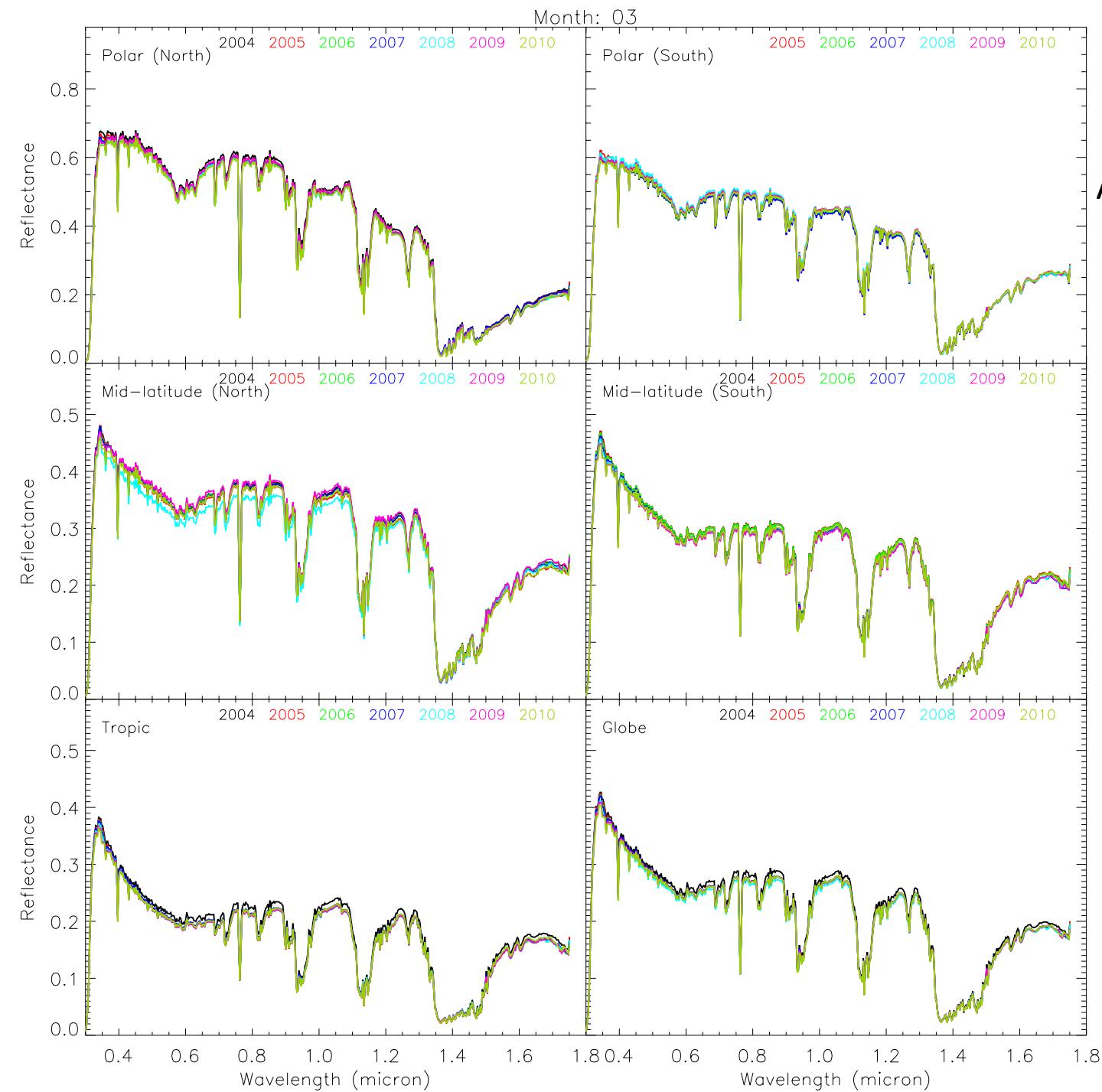
Model computation in each zone: land, ocean \rightarrow clear, cloud \rightarrow ice and water.

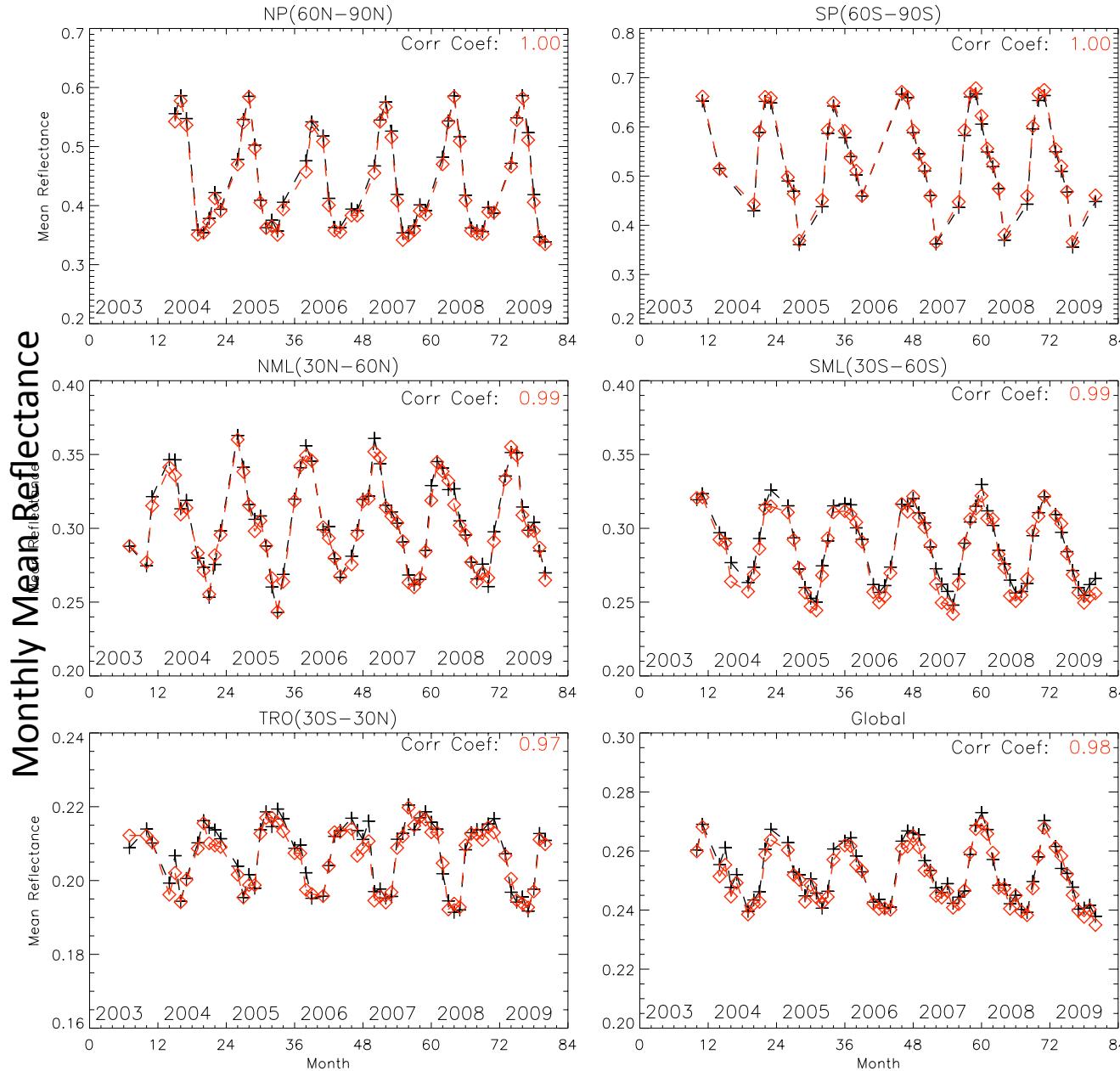
Zonal results are then averaged over the 5 large latitude regions and globe.



Month: 03
An example of SCIAM measured nadir solar reflectance averaged to the 5 latitude regions and globe.

(Each panel is for a different region, each color is for a different year.)

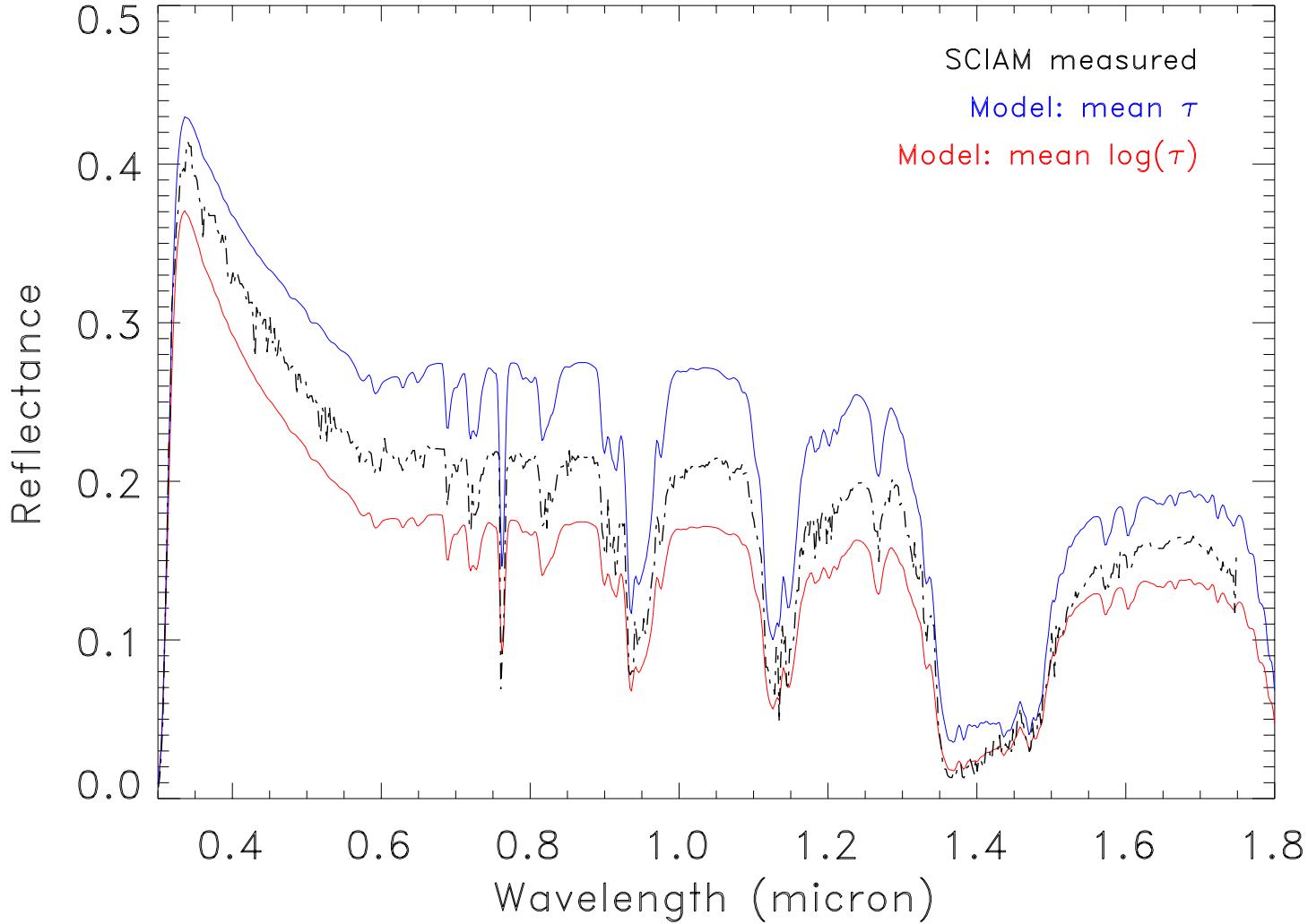




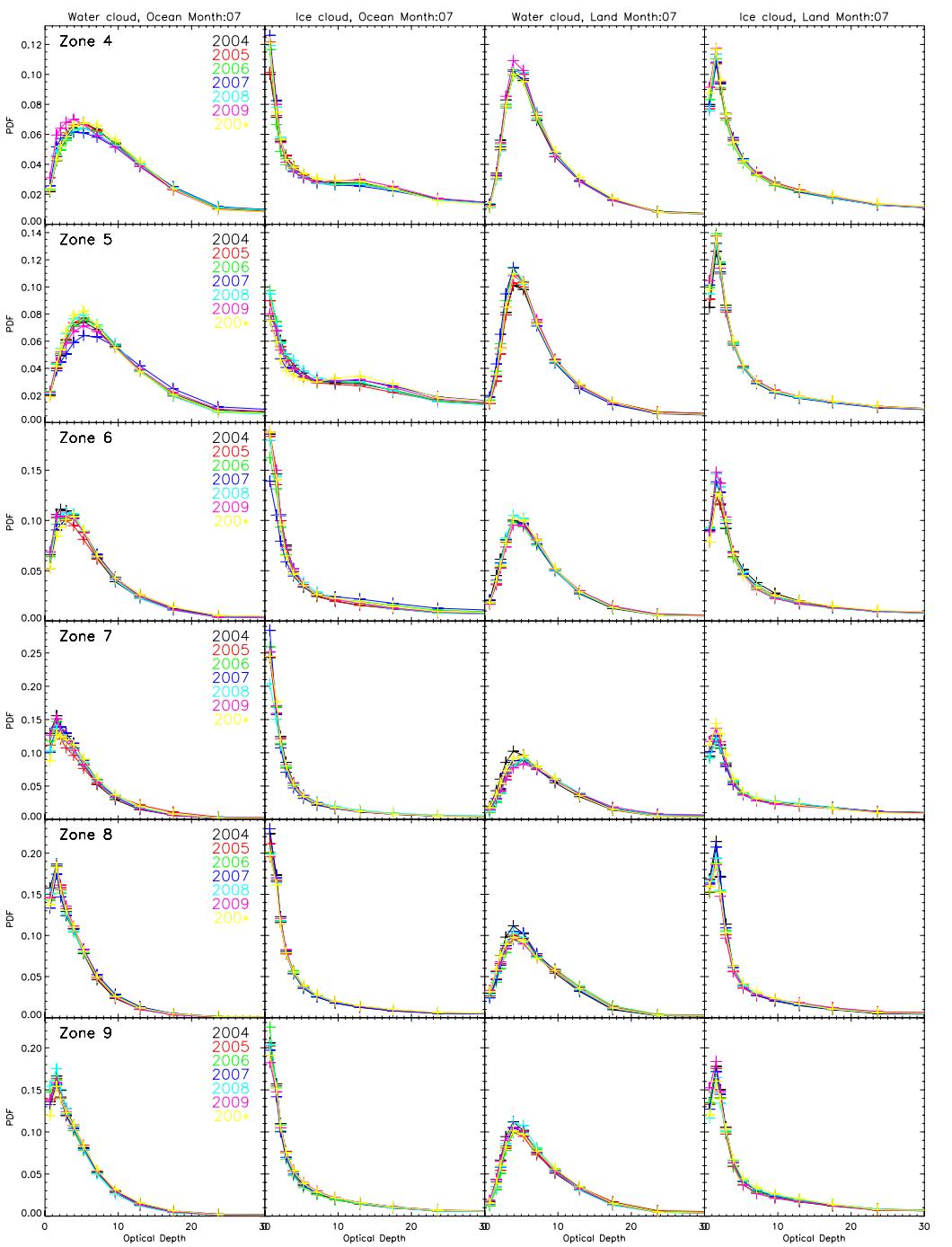
SCIAM in MODIS Ch1
MODIS Ch1 (640 nm)

When averaged to large domains, the two measurements are almost the same though they are not co-incident.

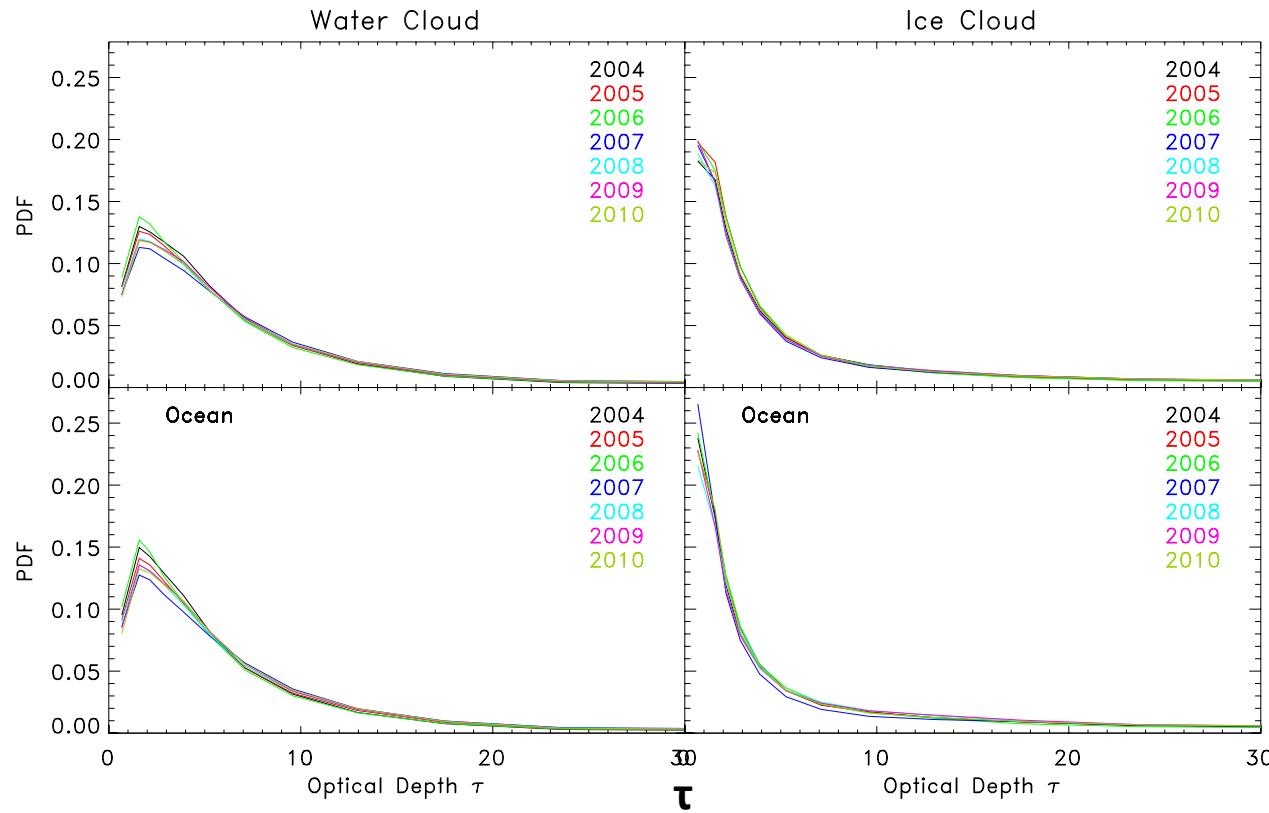
Comparison of monthly mean *nadir* reflectance (10°) between SCIAM and MODIS (Ch1) in 5 latitude regions and globe.



An example of model-observation comparison of spectral reflectance.
This example is for one zone (30S-35S) in the January of 2006.
(ocean only)



Cloud τ PDF in
different zones
(Data from CERES
SSF product)



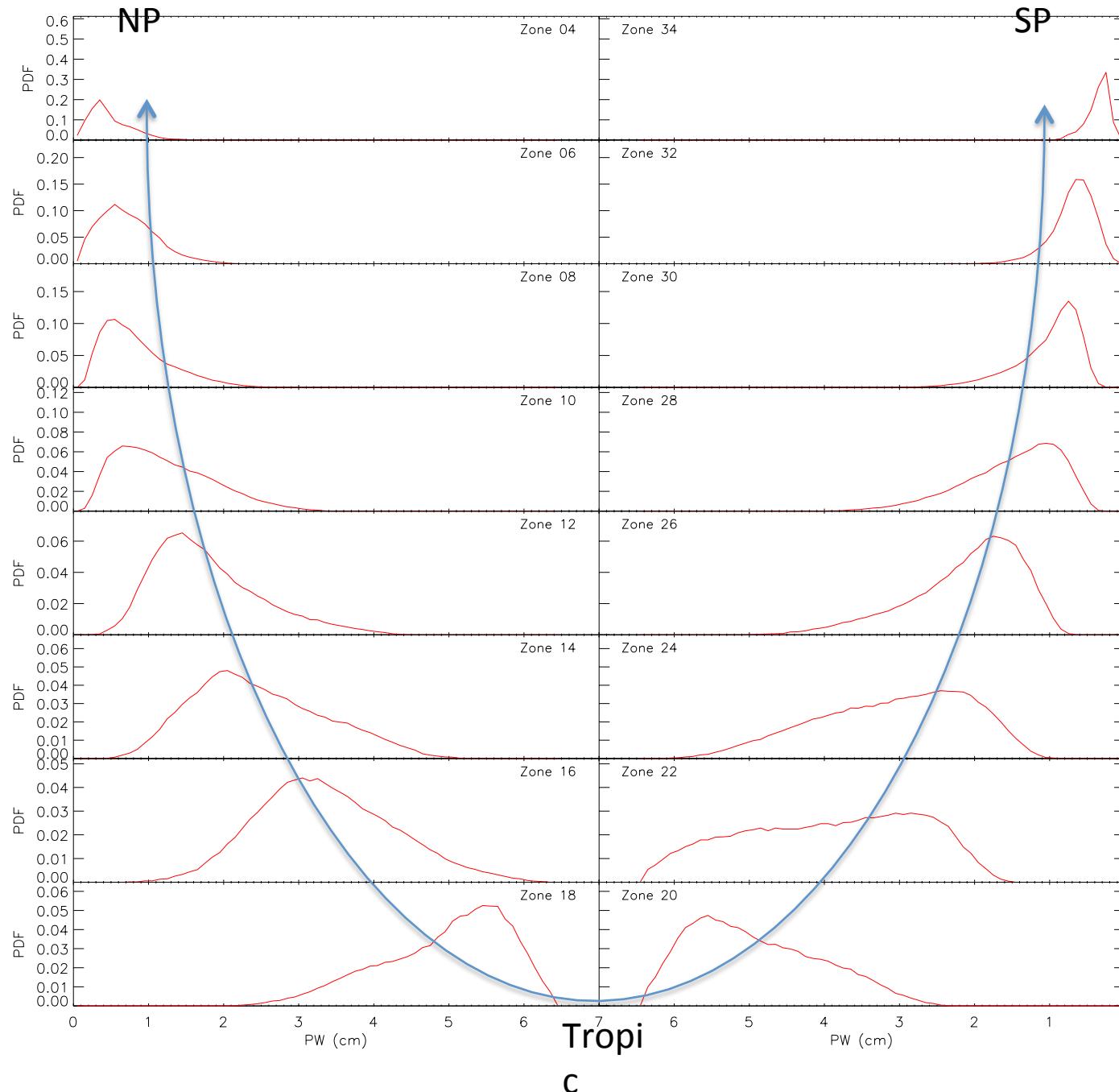
Example of
cloud τ PDF
In one zone

An example of the probability distribution function (PDF) of cloud τ in one latitude zone for months of April. A different color in each panel represents a different year.

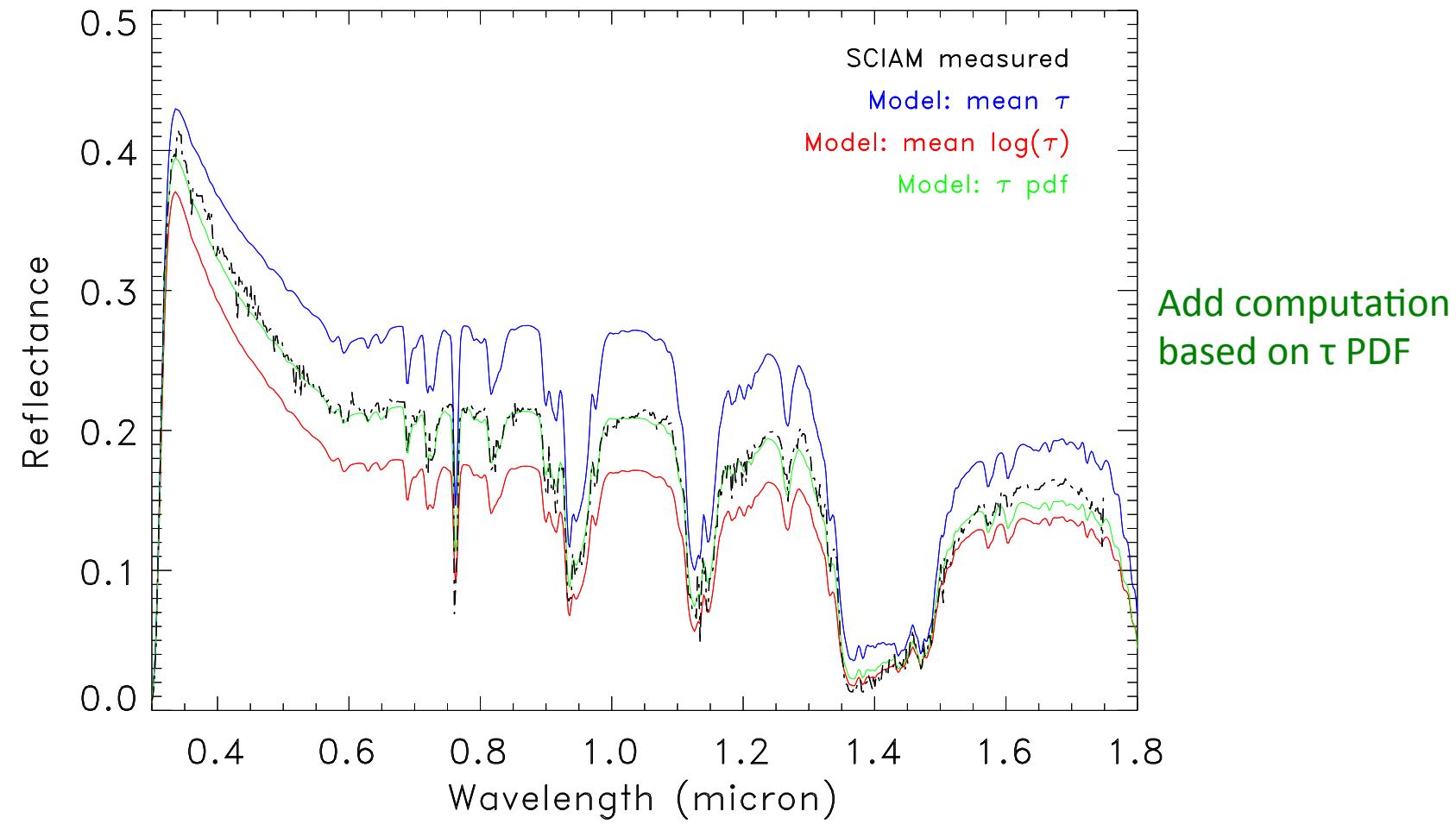
The cloud τ PDF is used in the RT modeling to account the large cloud variation from footprint to footprint.

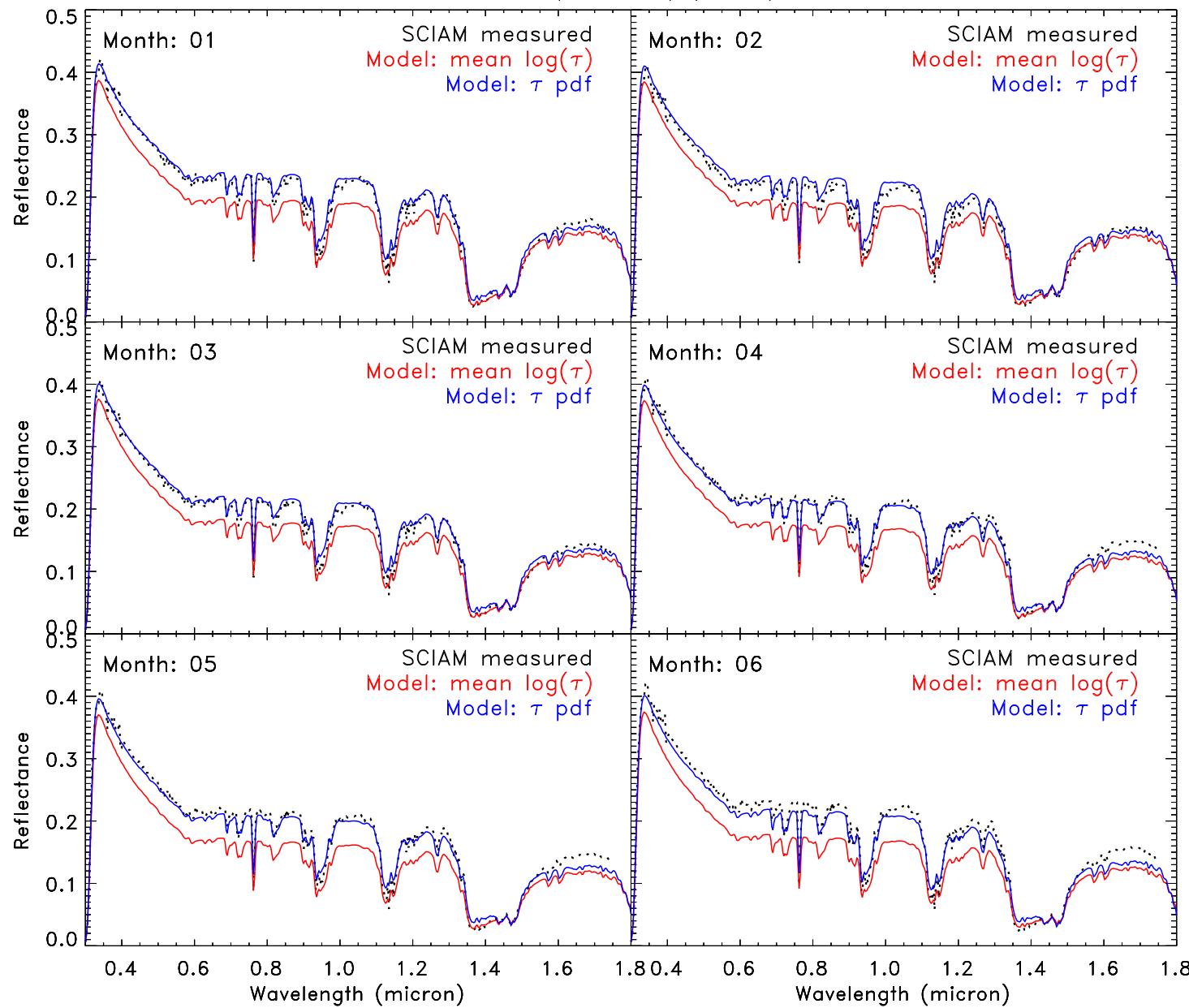
Month: 03

Month: 03



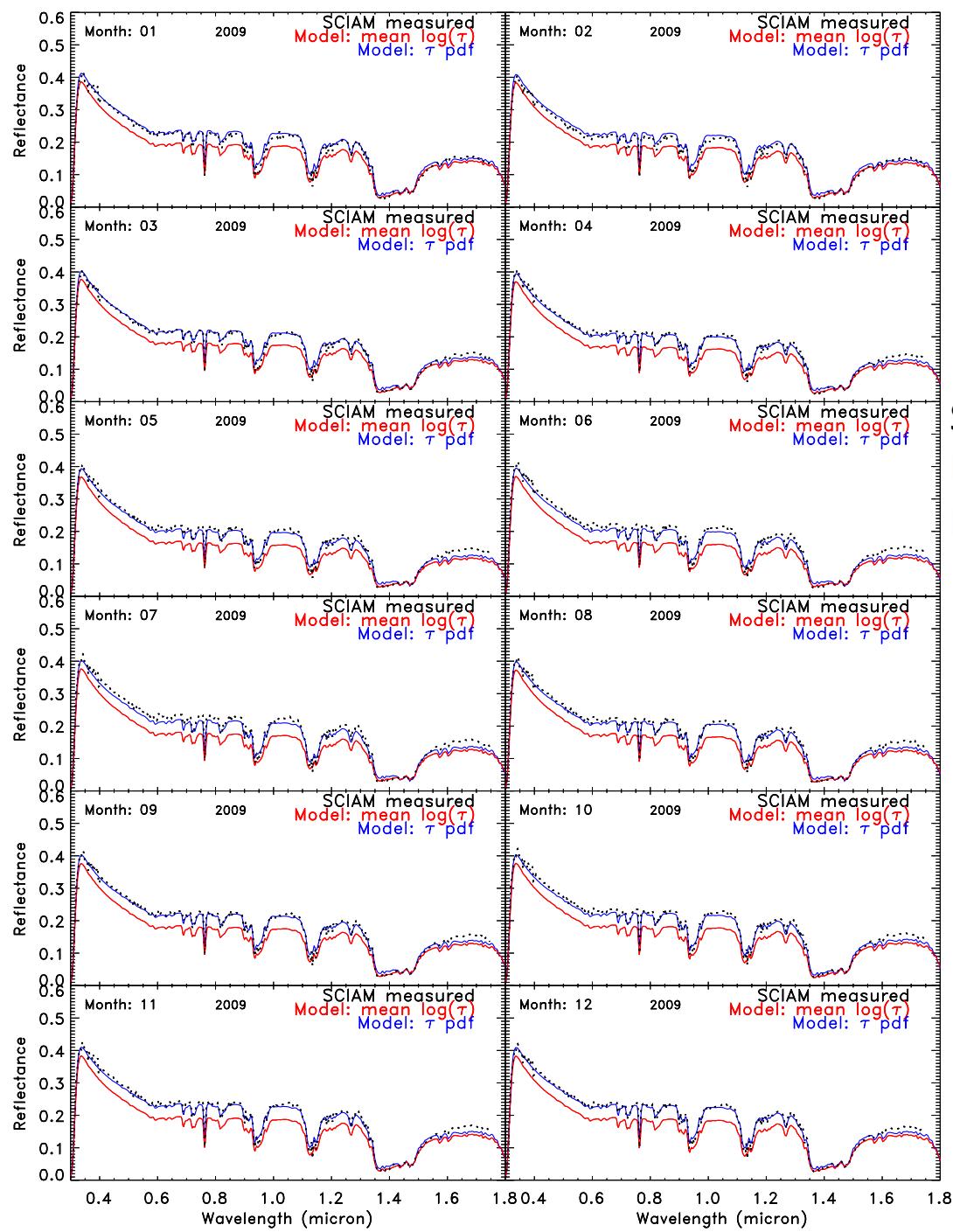
Water vapor
PDF
(data from
CERES SSF)





SCIAM measured
Model with mean τ
Model with τ PDF

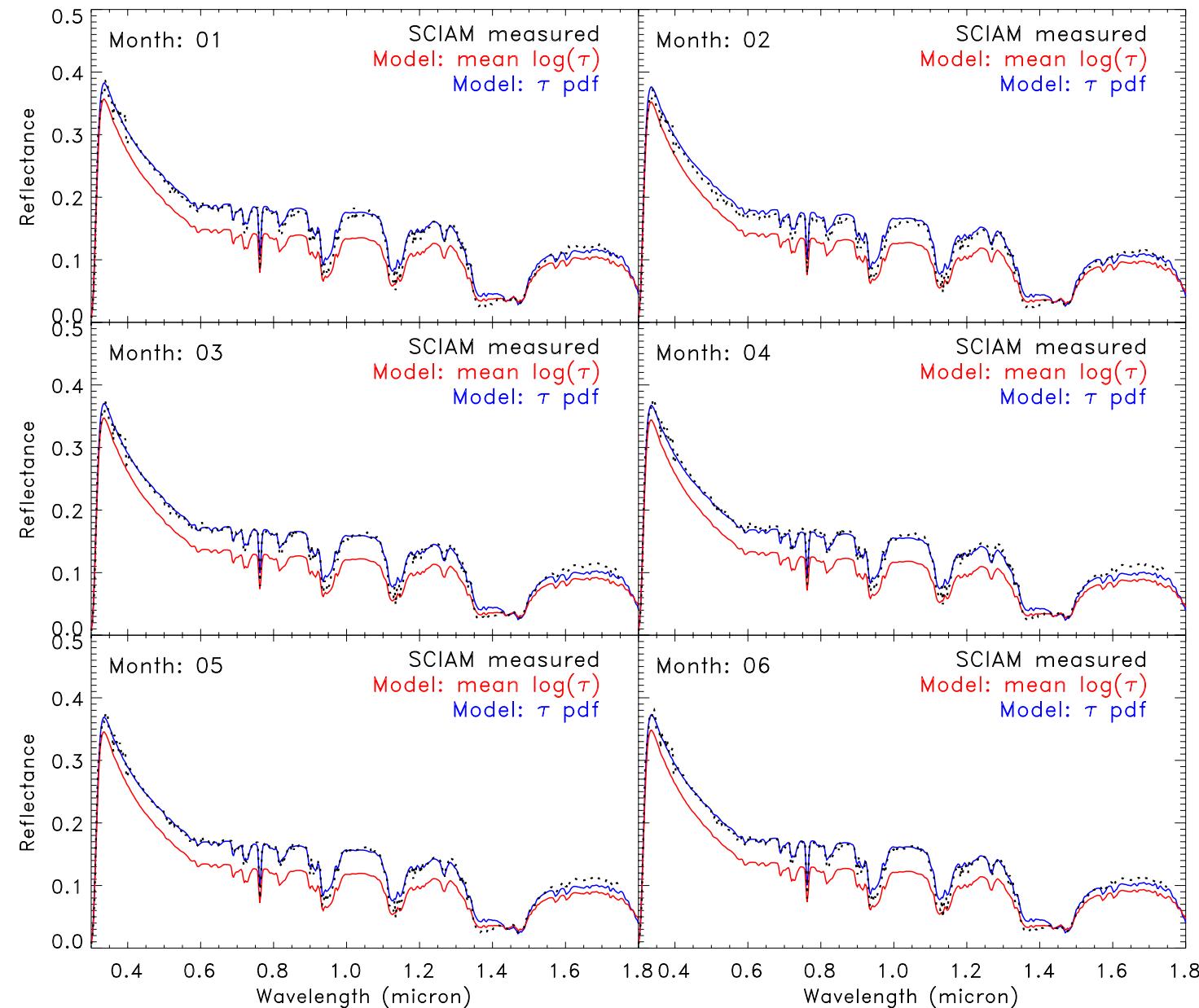
Comparison of observed and calculated monthly and globally averaged spectral nadir reflectance (ocean only).



A model-observation comparison over global ocean.

SCIAM measured
Modeled with mean cloud τ
Modeled with τ PDF

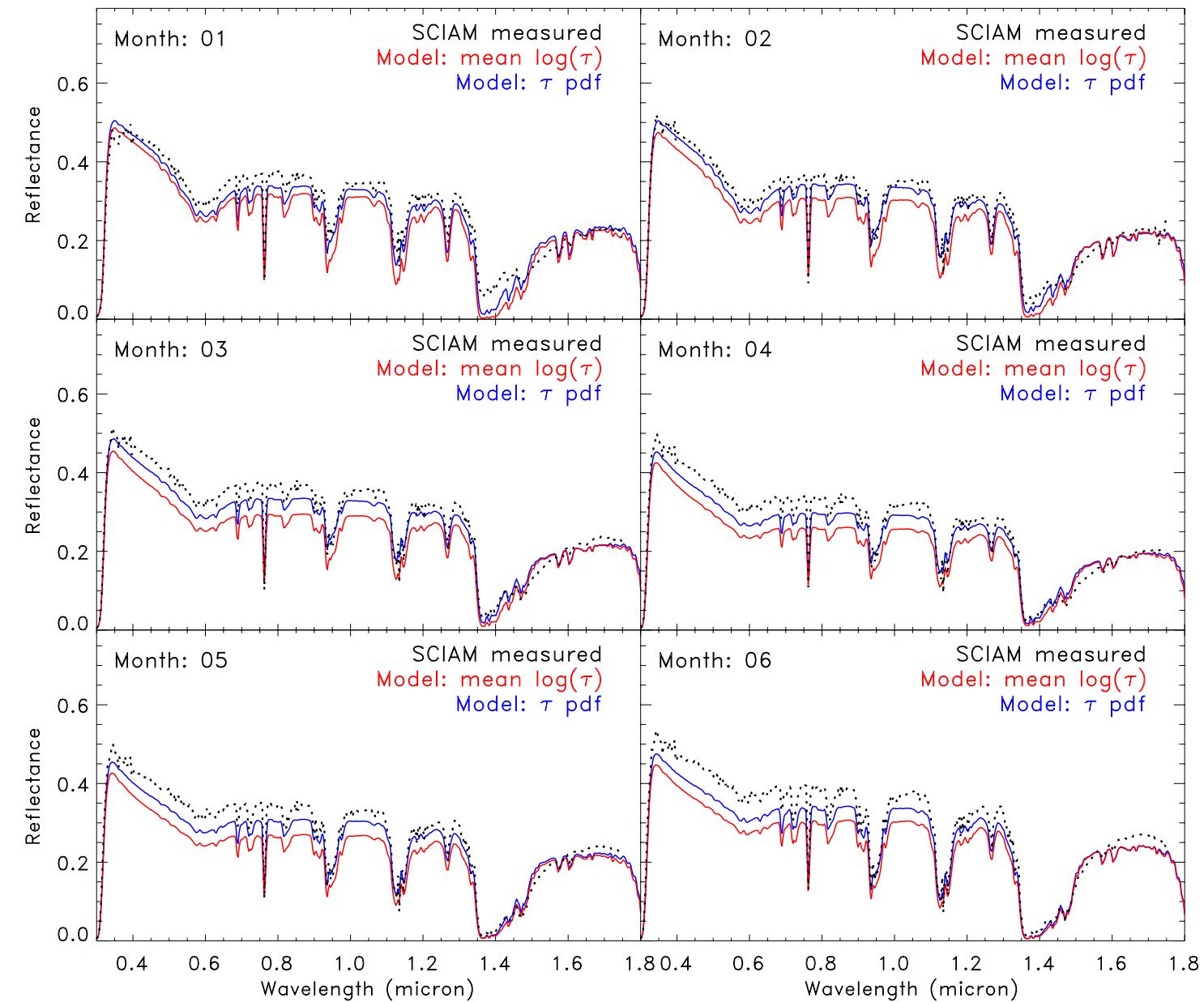
Tropic (ocean)



The largest improvement is in the tropic.

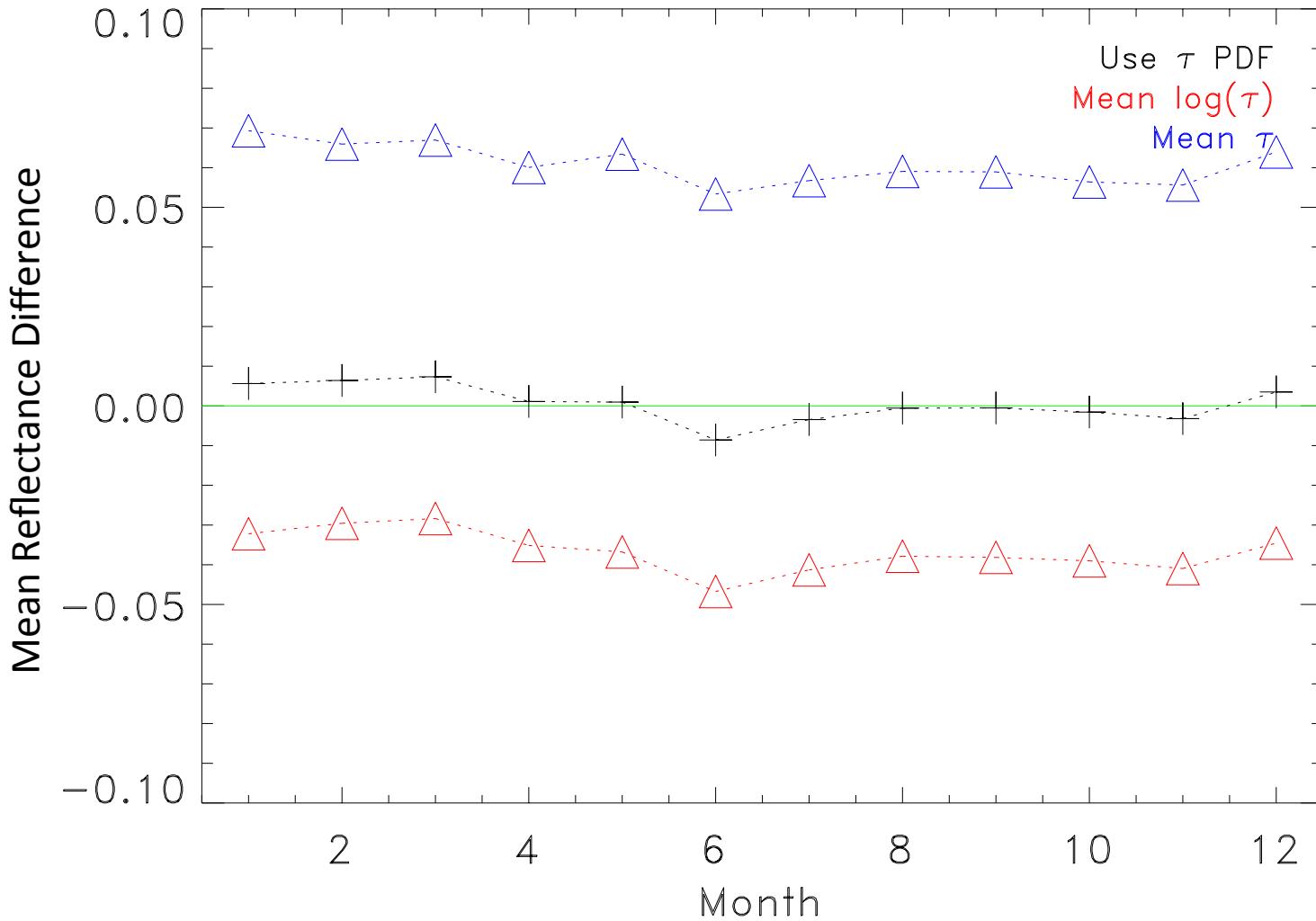
SCIAM measured
Modeled with mean τ
Modeled with τ PDF

Polar (North) (ocean)



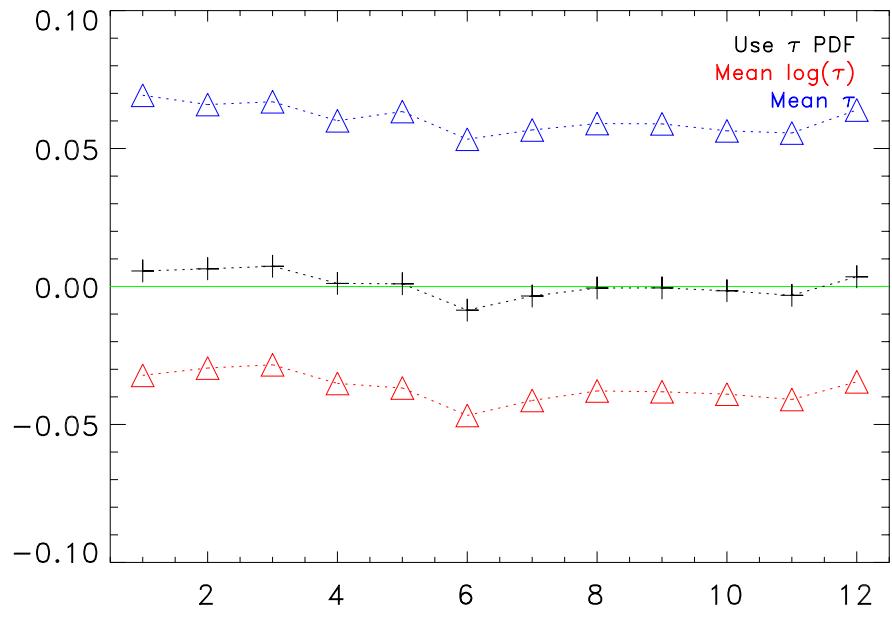
The least improvement is in the polar regions.

SCIAM measured
Modeled with mean τ
Modeled with τ PDF

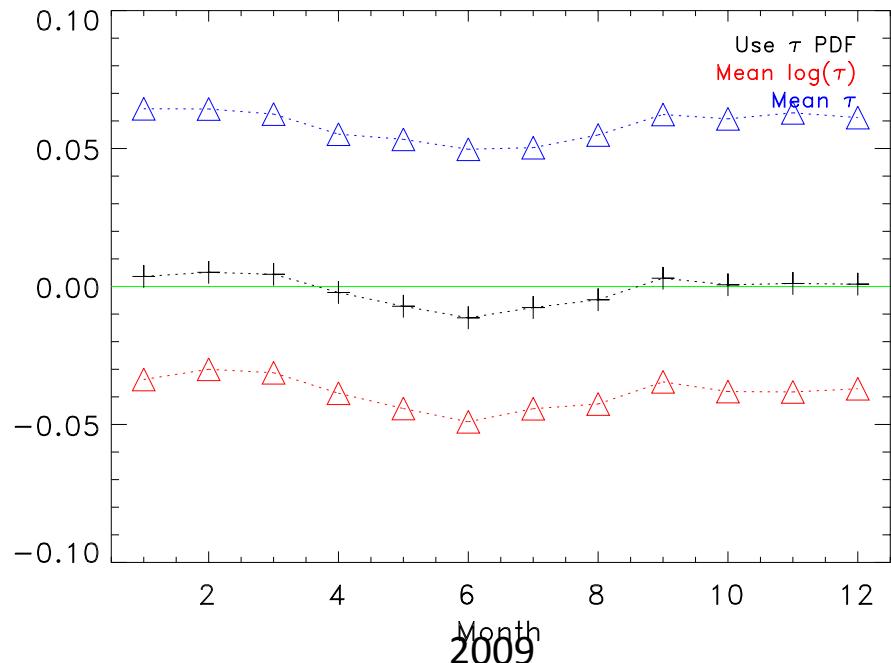


The mean model-observation differences in the integrated broadband reflectance (0.4-1.6 μm) for the three modeling approaches.
This example is for the global mean reflectance in the 12 months of 2006.

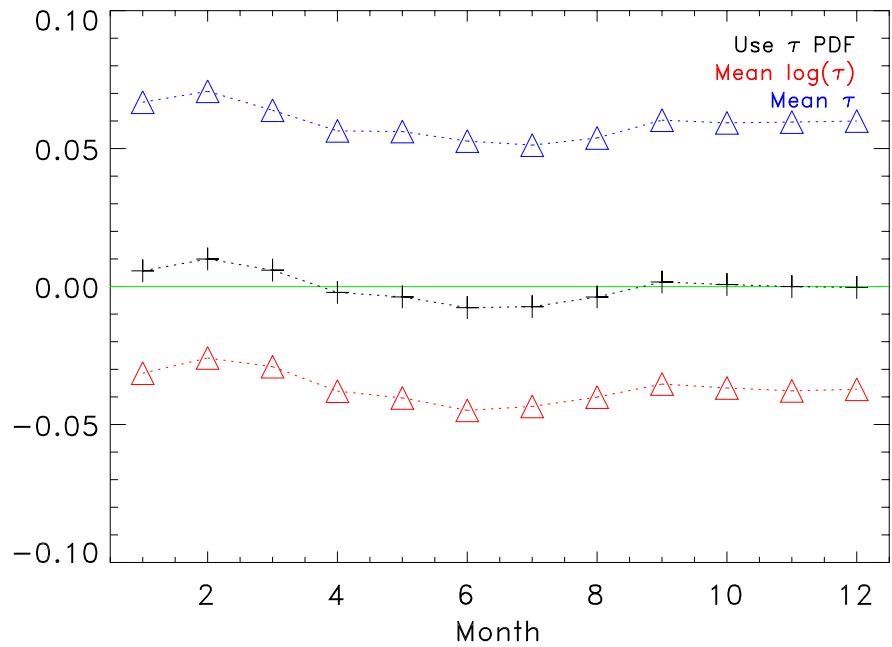
2006



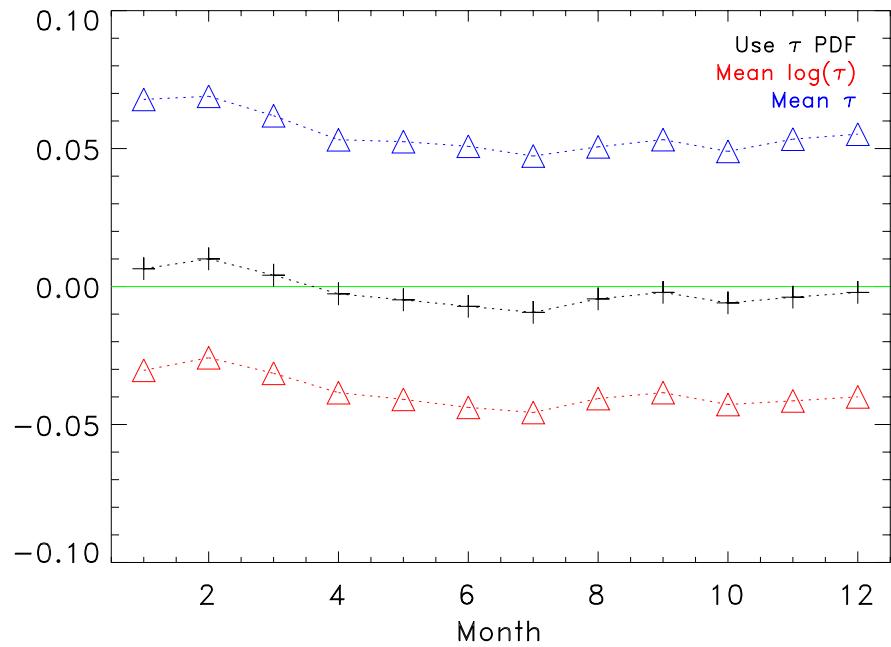
2007

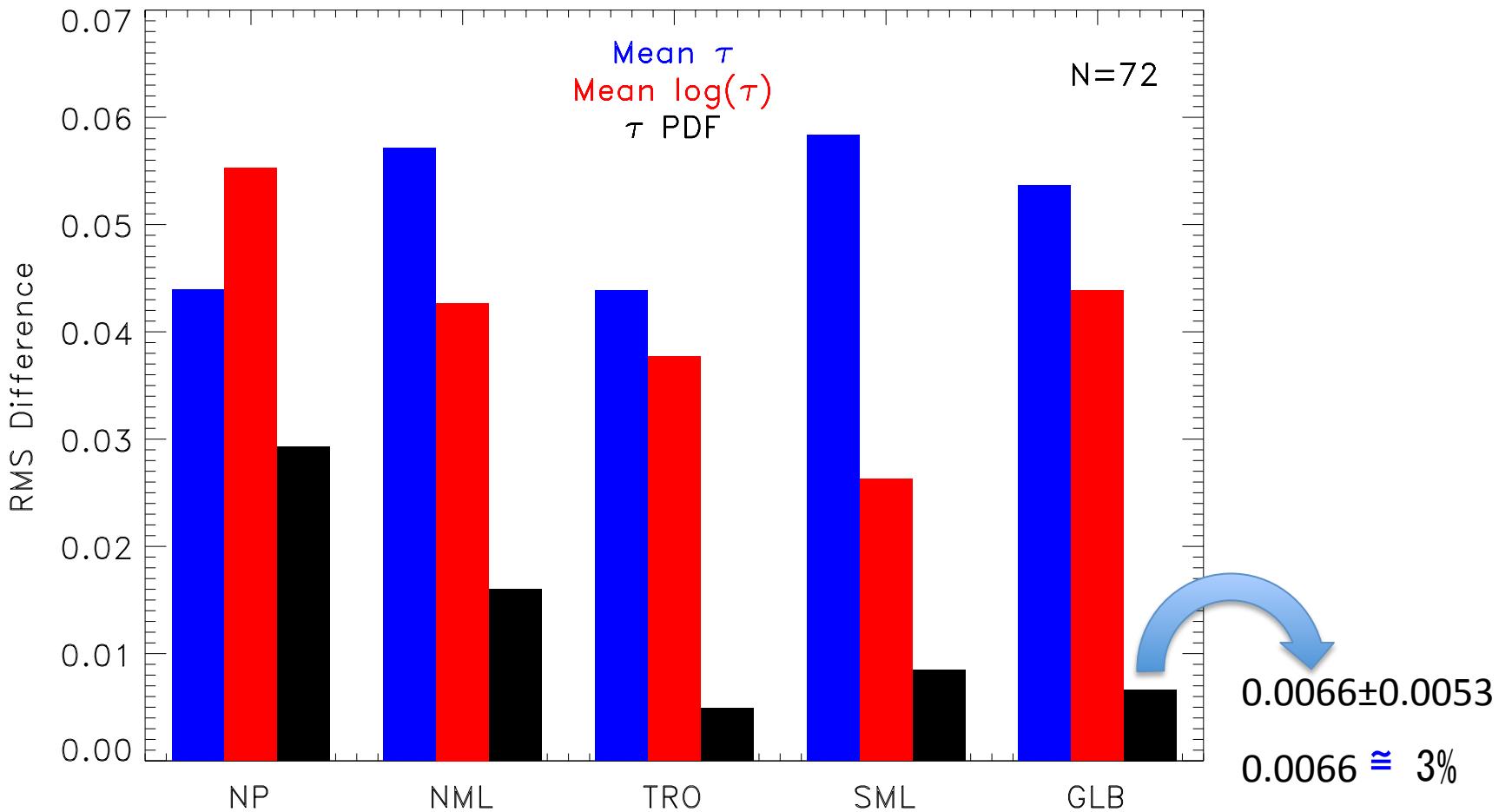


2008



2009





The RMS model discrepancy in the monthly mean reflectance in the five latitude regions (based on the results in the 72 months from 2004 to 2009). Each color bar represents a RMS error for a different modeling approach.

Summary

- 1) Because of the nonlinearity, the domain-averaged spectral radiances calculated from the simple domain-averaged input parameters show significant errors.
- 2) We have developed the cloud PDF based method, which can reduce the nonlinearity error substantially. This new approach is applied to MODIS/CERES data and the simulated spectral reflectance agrees with SCIMACHY measurements well.
- 3) The PDF approach introduced here provides a simple, fast and effective option in obtaining the mean spectral reflectance in large climate domains using large volume of instantaneous satellite data. Therefore, it is useful for the spectral solar benchmark simulation and fingerprinting for CLARREO.

Acknowledgement:

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